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ORIGINAL ARTICLE BODY CONTOURING

Surgical Calf Augmentation Techniques: Personal Experience, Literature Review and Analysis of Complications

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Abstract

Background More attention is paid to calf appearance, both in males and females, and several surgical techniques are available. Different studies have been published over time for calf augmentation, but, to the best of our knowledge, no comprehensive literature review and complications analysis have been published.

Objectives The aim of the study is to analyse the overall complication rate of calf augmentation surgical procedures and complication rates associated with the investigated techniques, namely subfascial implant placement, submuscular implant placement and fat grafting or lipofilling. Demographic analysis, including age and gender, is also performed.

Materials and Methods A literature review on the PubMed database was performed for clinical studies regarding calf augmentation surgical procedures. The authors selected and analysed 26 articles among the actual literature on this field and reported personal experience in calf augmentation surgery.

Results Twenty-six studies, published from 1993 to 2018, were included in the study for a total amount of 1498 patients, with a total of 2629 calves treated. Three different surgical techniques have been reviewed, excluding medical procedures: subfascial implant augmentation (n = 1929), submuscular implant augmentation (n = 435) and fat grafting (n = 265). The overall complication rate was 4.4883%. Calf augmentation with subfascial implants presented a total complication rate of 5.702%. The submuscular implant placement complication rate was 0.92%. Fat grafting presented a global complication rate of 1.509%.

Conclusions Calf augmentation, with all reviewed surgical techniques, has a low rate of complications compared to other body contouring procedures, but a high rate of satisfaction among patients. Fat grafting has the lowest rate of complications, but multiple sessions are required. Specific complications of implants, such as capsular contracture, malposition or rupture, are less common compared to the use of implants for other cosmetic purposes. Procedures should always be performed by experienced plastic surgeons.

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Keywords Calf augmentation · Calf implants · Lipofilling · Body contouring

Introduction

Calf augmentation procedures are becoming more popular among both males and females, since higher attention of the calves themselves and on the overall leg appearance is paid. The global tendency is to achieve a less-skinny look, with a more athletic aspect, and correct, if present, loss of volume in the region or a genetic muscle deficiency. Several techniques are available: cosmetic procedures include injections of reabsorbable fillers such as hyaluronic acid [1]

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or permanent fillers (like PMMA) [2]. Different surgical options are available, including the use of silicone implants, in the subfascial or submuscular plane, and volume correction with fat grafting (lipofilling). The aim of this paper is to review all the complications associated with the previously mentioned techniques for calf augmentation and to report the authors' personal experience with calf augmentation surgery.

Materials and Methods

A systematic review was performed using the PubMed database from its inception to May 2018 and using the medical subject heading search terms: "Calf prosthesis" OR "Calf augmentation" OR "Calf implant(s)" OR "Calf lipofilling". The search was performed independently in parallel by all authors.

Inclusion criteria: articles describing calf augmentation and surgical procedures in plastic and reconstructive surgery, including aesthetic plastic surgery and orthopaedic surgery. The full text should be available and should be in English. If two or more articles from the same author or group of authors presented overlapping data, only the article with the greatest amount of data was included in the literature review.

Exclusion criteria: experimental studies, reviews, comments, letters to the editor, animal studies and non-indexed articles. The initial search with all search terms resulted in 1368 articles. Two independent authors read the articles obtained with the initial search to discriminate the studies that met the inclusion criteria. Selected articles were completely analysed, and available data were recorded in a spreadsheet for statistical analysis. Statistical analysis was divided into two phases: firstly, the overall complication rate was analysed, independently from the surgical technique, and secondly complications were analysed based on the used surgical approach.

Results

After filtering the duplicates and the articles not meeting the including criteria, a total of 34 articles remained. Of these, the review articles and letters to the editor were subsequently excluded. This resulted in a total of 26 articles. The total number of patients who underwent calf augmentation was 1498, with a total of 2629 calves treated. Gender was taken into consideration for 943 patients (1517 calves) with 784 females and 159 males (female/male ratio of 4.93:1). Age ranges between 16 and 72 years.

The literature review evidenced 1929 calf augmentations with subfascial silicone implants, 435 calf augmentations with submuscular prosthesis insertion and 265 cases of fat grafting. The following information was documented and tabulated for each article: author name(s), year of publication, patients' demographic data, surgical technique, outcomes and complications rate. The literature analysis is shown in Table 1.

Over 2629, a total of 118 complications were recorded, independently from the type of surgical technique. Therefore, the overall complication rate was 4.4883%. Calf augmentation with subfascial implants presented a total complication rate of 5.702%. The most common complication was seroma (39 cases, 2.02%). Other complications included implant migration (15 cases, 0.77%), pathological scar (12 cases, 0.62%), wound dehiscence (12 cases, 0.62%), infection (5 cases, 0.25%), capsular contracture (5 cases, 0.25%), sensitivity alterations (5 cases, 0.25%), implant palpability (3 cases, 0.15%), anterior compartment syndrome (2 cases, 0.103%), implant rupture (2 cases, 0.103%), hematoma(s) (2 cases, 0.103%), implant extrusion (2 cases, 0.103%) and facial disruption (1 case, 0.05%). In 5 cases (0.25%), the implant was not tolerated and therefore removed (Table 2).

Fat grafting presented a global complication rate of 1.509%. Recorded complications were hyperpigmented scar (1.13%) and transient hypoesthesia (0.37%). No major complications such as fat embolism or donor-site seroma were recorded.

For calf augmentation with submuscular implant placement, the recorded complication rate was 0.92%, with 2 cases of wound dehiscence (0.46%), 1 case of upward migration (0.23%) and 1 case of necrotizing fasciitis (0.23%).

Among the several techniques, subfascial implant placement, which was the most commonly used, had the highest rate of complications compared to the other techniques such as fat grafting and submuscular implant placement (5.702% vs. 1.509% and 0.920%), but the rate of complications is relatively low compared to other implant techniques for body contouring such as gluteal augmentation [3], breast augmentation [4] and pectoral implants for male chest enhancement [5]. The most common complication is represented by seroma, which is defined as fluid accumulation, and represents 32.19% of the overall complications. No complication was life-threatening, but the most severe, necrotizing fasciitis, happened after a submuscular implant placement (see Table 3).

Fat grafting is a safer option, but the need for multiple surgeries should be considered, both energetically and economically, by the patients. In our literature review, the rate for touch-ups was 41.13% (109/265 cases). In particular, 46 patients underwent two surgeries (17.35% of fat grafting patients, counting as 42.20% among the multiple surgeries patients' group), 40 underwent three surgeries

Table 1 Literature analysis of published articles about calf augmentation

Study	Year	Cases	Female/male	Age	Surgical technique	Notes	Complications
Andjelkov et al. [6]	2018	72 (73 calves)	54 F; 18 M	22–57 (34.67)	Calf augmentation Subfascial	69 medial calf augmentation with silicone implant; 3 medial and lateral calf augmentation. 48 patients underwent fat grafting (no complications recorded). Implants vary from 85 to 180 cc	1 Hyperpigmented scar; 1 partial dehiscence
Niechajev and Krag [7]	2017	50 (60 calves)	31 F; 19 M	17–59	Calf augmentation Subfascial	23 aesthetical correction, 6 bodybuilders, 21 reconstruction. 38 medial implants, 11 medial and lateral implants, 1 medial, lateral and anterolateral custom made implant	1 upward migration; 1 partial dehiscence; 2 hyperpigmented scar; 1 seroma; 1 acute compartment syndrome
Andjelkov et al. [8]	2017	134 (207 calves)	84 F; 50 M	NR	Calf augmentation Subfascial	108 primary augmentation (47 bilateral, 61 monolateral); 26 secondary cases	1 infection; 1 hyperpigmented scar
Skorobac Asanin and Sopta [9]	2016	48 (96 calves)	48 F	20–54	Calf augmentation with fat grafting	11 reoperations	No complications
Yazar et al. [10]	2016	10 (10 calves)	10 F	26–38 (32)	Calf augmentation with fat grafting	All cases were patients with leg asymmetry due to polio infection. 7 cases of two surgeries; 3 patients with three surgeries	1 transient hypoesthesia
Seo et al. [11]	2015	1	1 F	50	Calf augmentation Subfascial		Capsular contraction
Mundinger and Vogel [12]	2015	13 (23 calves)	10 F; 3 M	29–65 (45)	Calf augmentation with fat grafting	4 reoperations	3 hyperpigmented scars
Karacaoglu et al. [13]	2013	22 (44 calves)	20 F; 2 M	23–44	Calf augmentation Submuscular	Aesthetical purpose	1 wound dehiscence; 1 upward migration
Hoppmann et al. [14]	2013	5 (10 calves)	3 F; 2 M	28–56 (42.8)	Calf augmentation with fat grafting		No complications
Perez-Garcia et al. [15]	2013	1	1 M	26	Calf augmentation Submuscular		Necrotizing fasciitis
de la Pena-Salcedo et al. [16]	2012	63 (126 calves)	NR	16–67 (39)	Calf augmentation Subfascial		1 infection; 27 seromas; 9 wound dehiscence; 4 severe capsular contraction; 2 implant rupture; 5 implant displacement; 3 numbness at ankle
Pereira et al. [17]	2012	53 (106 calves)	40 F; 13 M	25–51 (29.5)	Calf augmentation Subfascial	Aesthetical purpose	3 seromas; 8 hyperpigmented scars; 1 removal
Datta et al. [18]	2008	1	1 F	54	Calf augmentation Subfascial	Posttraumatic loss of the soleus and gastrocnemius	1 implant displacement
Erol et al. [19]	2008	77 (144 calves)	NR	20–35 (25)	Calf augmentation with fat grafting	17 cases of 2 surgeries; 37 patients with three surgeries; 23 patients with 4 surgeries	No complications

Table 1 continued

Study	Year	Cases	Female/male	Age	Surgical technique	Notes	Complications
Gutstein [20]	2006	15 (30 calves)	3 F; 12 M	25–51	Calf augmentation Subfascial	9 congenital hypoplasia; 1 polio atrophy; 2 traumas; 1 clubfoot; 1 burn scar	1 wound dehiscence
Nunes and Garcia [21]	2004	159 (318 calves)	NR	NR	Calf implant Submuscular		No complications
Kalixto and Vergara [22]	2003	6 (11 calves)	5 F; 1 M	26–44 (35)	Calf implant Submuscular		No complications
Dini [23]	2002	11 (22 calves)	4 F; 7 M;	21–35	Calf augmentation Subfascial	1 polio atrophy	No complications
Rigg [24]	2000	79 (153 calves)	61 F; 18 M	21–60 (27)	Calf augmentation Subfascial	67 cosmetic cases, 12 reconstructive cases. Two revision cases	1 wound dehiscence; 1 hematoma; 4 implant malposition; 2 nerve damage (temporary); 1 fascial disruption; 2 seromas
Carlsen [25]	1996	256 (524 calves)	NR	NR	Calf augmentation Subfascial		1 anterior compartment syndrome; 1 late seroma; 1 implant extrusion
Szalay [26]	1995	163 (312 calves)	162 F; 1 M	23–55	Calf augmentation Subfascial		1 upward migration; 1 extrusion; 1 infection
Durak [27]	2011	32 (61 calves)	29 F; 3 M	20–46	Calf implant Submuscular		1 wound dehiscence
Dini [23]	1999	91 (172 calves)	88 F; 3 M	18–72	Calf augmentation Subfascial		1 infection; 2 postoperative displacement; 1 hematoma
Lemperle and Kostka [28]	1993	14 (28 calves)	13 F; 1 M	18–52	Calf augmentation Subfascial		1 palpable edge; 1 seroma
Felicio [29]	2000	100 (200 calves)	95 F; 5 M	NR	Calf augmentation Subfascial	95 cosmetic cases; 3 polio atrophy; 2 asymmetric cases	4 seromas; 4 implant removal; 1 implant malposition
Hendy [30]	2010	22 (44 calves)	15 F; 0 M	19–39	Calf augmentation with fat grafting	7 touch-ups for fat grafting	No complications
			7 F; 0 M		Calf augmentation Subfascial		1 infection; 2 cases of palpable lower edge

Table 2 Analysis of the overall number and percentage of complications for calf augmentation surgery

Surgical approach	Complications rate	Percentage
Subfascial implant placement	110	5.702
Fat grafting	4	1.509
Submuscular implant placement	4	0.920

Table 3 Overall complication rates and percentages for type of complications

Complications	Total number	Percentage
Early or late seroma	39	1.483
Implant migration or displacement	16	0.609
Scar complications (hyper- or hypopigmentation)	15	0.571
Partial or total wound dehiscence	14	0.532
Nerve damage (permanent or transient)	6	0.228
Infection	5	0.190
Implant removal	5	0.190
Capsular contracture	5	0.190
Implant palpable edge(s)	3	0.114
Implant rupture	2	0.076
Implant extrusion	2	0.076
Hematoma	2	0.076
Compartment syndrome	2	0.076
Necrotizing fascitis	1	0.038
Fascial disruption	1	0.038
Total number of complications	118	4.488

(15.09% of fat grafting patients, counting as 36.69% among the multiple surgeries patients' group) and 23 underwent four surgeries (8.68% of fat grafting patients, counting as 21.11% among the multiple surgeries patients' group). Furthermore, donor-site complications were not mentioned and therefore not analysed.

In our personal case series, from 1996 to 2017, 46 patients underwent bilateral calf augmentation for cosmetic purposes except for three patients, with polio sequelae and therefore required monolateral surgery. Eleven patients, who underwent surgery up to 1999, have been analysed in a previous work published by one of the authors [23]. The mean age at time of surgery was 24 years, with 13 females (28,27%) and 33 males (71,73%). All patients underwent subfascial augmentation under local anaesthesia with prostheses with volumes ranging from 85 to 180 ml. No major complications were recorded. Three patients suffered from hypertrophic scars, of which only one required a surgical scar revision. Three patients reported seroma, of which only two required percutaneous drainage under ultrasound. One patient required implant removal because the implants were not tolerated and subsequently required bilateral implant removal. No cases of capsular contraction, infection or implant malposition have been recorded at the minimum follow-up of 12 months. Postoperative compressive garments were applied for at least 1 week after surgery (see Table 4).

Table 4 Authors' reported case series for calf augmentation surgery

Number of patients	46 (89 calves)
Female/male ratio	13/33 (F: 28,27%; M: 71,73%)
Mean age	24.7 (from 19 to 36)
Mean follow-up	16 months
Mean implant volume	142 ml (from 85 to 180)
Complications	Seroma (3.37%)
	Hypertrophic scar (3.37%)
	Implant removal (2.27%)

The complication rate is similar to the percentage obtained from the literature review thus to reinforce the reliability of the technique.

Discussion

Legs are considered a very important unit to be considered, both functionally and aesthetically, and so-called skinny legs are commonly held to be aesthetically negative in both men and women and nowadays perceived as an asset of a healthy lifestyle, and therefore, the use of alloplastic prosthesis is becoming more accepted and increasingly requested worldwide. Calf augmentation procedures are indicated for patients with thin legs, as a personal habitus or as a result of previous disease or trauma, or patients with disproportion with tights volume (especially bodybuilders). Menichelli Netto classified the leg deformities into four different groups: thin legs, arched legs (caused by hypoplasia of the gastrocnemius and/or genus varus), divergent legs (caused by genus valgus) and asymmetrical legs caused by congenital pathological conditions or acquired atrophies [31]. Calf implants create cosmetic fullness, when required, in the lower leg and can help patients who, even after extensive physical activity, cannot achieve the look they desire and can help to reproportionate the whole body appearance. In this review, only surgical approaches for calf augmentation are taken into account and therefore no medical approaches (such hyaluronic acid injections) are compared. Several techniques are proposed for calf augmentation with the use of alloplastic implants. The first technique was proposed by Carlsen in 1979, with the use of solid silicone implants in the subcutaneous pocket, with a high rate of capsular contraction and unnatural results [32, 33]. In 1991, Carlsen proposed the subfascial

placement and the dramatic improvement in the quality of the prosthesis material decreased the rate of complications such as rupture or capsular contraction [34]. In 2003, Kalixto and Vergara [22] proposed for six patients the use of a submuscular pocket harvested between the gastrocnemius and the soleus. In 2005, Niechajev proposed inserting the silicone implant through a pocket made between the investing crural fascia and the gastrocnemius epimysium membrane.

According to this review, calf augmentation with subfascial placement is the most common technique, even if the overall complication rate is higher compared to the submuscular placement. Subfascial placement is the most common choice among surgeons because of its easily reproducible and reliable technique, with a high satisfaction rate because consistent and cosmetic outcomes are appreciated. Autologous fat grafting is associated with a lower grade of complications, but multiple touch-ups are required. The main advantage of the technique is that fat removal from specific areas such as trochanteric, abdominal or subgluteal regions can help patients to reach a more proportional figure, but should be performed only by board-certified plastic surgeons to avoid skin irregularities or deformities in the donor region and an adequate anticoagulant prophylaxis for VTE and fat embolism should be administered.

During the submuscular technique, the implant is placed below the deep fascia, avoiding the union of the gastrocnemius muscles to avoid accidental injury to the sural vein and nerves. The main advantages are represented by the lowest rate of complications and non-palpability of the implant, since the calf contour is represented by muscles and not by the implant, but the procedure is more painful compared to the subfascial technique and major discomfort during the first week is noticed while walking.

The authors' choice is subfascial augmentation because of its less invasive technique and reliability.

In the authors' opinion, subfascial placement of the implant, despite a slightly higher rate of minor complications, is less invasive but as effective as submuscular placement. The authors suggest the use of implants only in patients with adequate tissue coverage to avoid implant visibility and palpability. Patients requiring a very muscular appearance must be aware that implants can be visible, with a less natural look. Fat grafting can be an effective option in patients requiring a more natural look: ideal patients for fat grafting are patients with localized fat deposits in the legs and therefore fat grafting, reducing fat accumulation and adding volume to the calves, can balance the overall appearance of the legs, creating a more proportioned whole figure. The authors suggest the use of small-size implants: the aim of this type of surgery, more than a volumetric enhancement, is a cosmetic reshaping of the legs. With this in mind, the proper implant position, correcting a profile deficiency, is more important than dramatic volume increases. Furthermore, the use of well-placed small implants reduces the risk for complications and decreases the downtime, with a more rapid recovery and return to normal daily routine.

The article contains different bias: follow-up time is not standardized, surgeon's experience, morphologic assessment of the population. Moreover, there is no general consensus for the fat purification technique. These biases are common to the literature review, but as authors we believe that the main goal to assess the complications for calf augmentation is still not modified.

Conclusions

Calf augmentation procedures are gaining popularity because of the increasing attention to the appearance of the lower legs. Several techniques are proposed, including the use of a prosthesis or lipofilling. To the best of our knowledge, there are currently no literature reviews comparing the different techniques for calf augmentation. The subfascial placement of the implants has a reliable and easy-to-reproduce-technique, with a lower rate of complications. Compared to other major cosmetic procedures, complications are acceptable and the risk of major damage is virtually absent. Fat grafting offers different advantages, including no scarring (and therefore no risks for pathological scar) and the use of a completely autologous tissue under local anaesthesia, but it may require multiple sessions for touch-ups. Submuscular implant placement is an effective solution, mostly because implants are not palpable, but, due to the presence of vessels and nerves in the region, pocket dissection must be carefully performed to avoid major complications. All types of procedures should be performed by board-certified plastic surgeons to ensure patient safety.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest to disclose.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent For this type of study, informed consent is not required.

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